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Research Program on the

ORGANIZATION AND MANAGEMENT OF R AND D

The Attainment of Organization Goals Through Appropriate Selection of Sub-Unit Goals

by

A. Charnes* and A. C. Stedry**

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INTRODUCTION

In the growing body of research dedicated to increasing knowledge of organizational behavior many approaches and disciplines may be involved in the investigation of even a single problem. In this paper we are concerned with two approaches to organizational behavior, both of which possess a fairly high degree of internal consistency. The disparities which exist between these two bodies of thought, however, appear to exceed the level of a multi-faceted approach to a problem that might be considered to have beneficial results. While these disparities cover the entire area of organizational research, our emphasis will be on the problems of organizational control - i.e., the coordination of the activities of various subunits in the organization in order to attain the aims of the organization as a whole.

One body of thought in organizational research has evolved from theoretical economics but remains quite closely related to that discipline. Starting from an assumption that firms do (or should) maximize long-run profits the focus of research is on the means for attaining this aim. For example, some work of Koopmans (1951) deals with the design of transfer pricing systems for optimal production and distribution scheduling by subunits within the firm; Arrow (1964) deals with the design of internal organizational control schemes for profit maximization. Shubik (1964) treating the various subunits as players in a game, investigates the properties of different kinds of game rules--i.e., organization structures in game-theoretic terms--as they relate to overall profitability. Marschak (1954) investigates requirements for the optimal behavior of teams. This list could be made quite long and varied but we shall attempt a generalization. We include in this body of thought research which has the following characteristics: (1) explicit long-run profitability maximization assumed for the firm as a whole; (2) focus on the design of internal systems to achieve this aim; and (3) the rigorous use of mathematical tools in the solution of the organizational problems posed.

The second body of thought of particular interest here goes under the heading of the behavioral theory of the firm. Described in detail by Cyert and March (1963), it draws on the descriptive hypotheses of organizational behavior presented by Barnard (1938), March and Simon (1958) and others. The focus of this research is on the description and understanding of organizational behavior rather than its improvement. Although dependent in part on mathematical modeling the research has utilized observation, simulation, and laboratory experimentation extensively. The differences between these two bodies of thought can be conveniently classified into those of purpose and of underlying assumptions. The first has already been alluded to. The body of research which is most closely related to the traditional assumptions of economic theory has been devoted to the design of optimal systems; it is essentially normative, focusing on the best way of doing things, with the behavior or individuals within organizations and the aims of organizations to be known. The behavioral theory of the firm approach however, is essentially descriptive in character where the efficacy of extant organizations is taken as given but the actual behavior of individuals and the organization as a whole assumed as the subject for investigation.

It is not unusual, of course, in the physical sciences for one body of researchers to be concerned with the description and understanding of phenomena and another the design of devices to best utilize the phenomena. Nor is the problem simply that of degree of abstraction - e.g., the simplicity of the maximization assumptions compared with the relatively more complex behavioral descriptions hypothesized in the theory of the firm model. Much engineering design can be perceived as a process of using highly abstracted notions - e.g., the law of gravity - to extrapolate from a limited number of empirical observations a series of design curves for a variety of conditions whose effects

were not observed. The problem in organization research arises from a disparity between the abstraction used and empirical observation which cannot be explained as a result of simplification or approximation.

The abstraction that firms maximize profit is generally coupled with an assumption that individuals within the firm are "rational." That is, individuals act in such a way as to maximize their own gain. This gain, although in early economic studies assumed to be entirely expressible in monetary terms, has generally been broadened to the concept of "utility maximization." Utility is defined as the value to an individual of all of the things he can possibly enjoy or possess--including status, prestige, power, etc.,--beyond mere income or monetary worth. All of the non-monetary components are assumed, however, to be translatable into a single utility scale which, in essence, allows tradeoffs between the non-monetary and monetary components to be made; i.e., it is assumed that an individual could pay for additional prestige by taking a cut in income of an amount equivalent in "utiles" to the change in prestige without altering his total utility or satisfaction. The behavioral theory of the firm by contrast is rooted in the "satisficing" concept of individual behavior presented by Simon (1957). He argues convincingly that individuals search until a satisfactory solution is found (not an optimal solution) and that because of limits on human cognitive powers are not likely to combine their various sources of satisfaction into a single function, and certainly are not able to maximize such a function. They are likely to seek for satisfactory solutions in the several areas of their activities and, if tradeoffs between areas occur at all, they are likely to be quite limited in range.

These differences in assumptions carry over into the organizational behavior sphere not only in terms of the internal working of the firm but in terms of the aims assumed for organizations as a whole. In the behavioral

theory of the firm it is assumed that a "ruling coalition" formulates goals for organizational activity in several areas. The "rational man" assumption of economics at the individual level becomes profit maximization at the organizational level, in the maximization approach. If organizational aims are to be extended beyond profit maximization[1] an organizational utility function incorporating performance in these other areas is assumed and assumed to be maximized.

If, indeed, individuals are "satisficers" rather than "maximizers" and organizations are goal-striving rather than profit (or utility) maximizing, then the normative models for organizational design are lacking in two ways. The first is that their prescriptions are based upon faulty assumptions as to the way individuals and collections of individuals within the organization will respond to them. The second is that they are designs for the attainment of an organizational aim which organizations do not have and are thus unlikely to be operational in their present form. On the other hand, for those who consider normative research to be a valid endeavor, the economics-behavioral science amalgam of research known as "the behavioral theory of the firm" is disappointing in view of its almost complete absence of interest in the evaluation and improvement of organizational behavior. Organizational behaviors of certain kinds are postulated--in particular certain satisfactory levels of performance--but no great amount of attention has been paid to developing mechanisms for formulating better goals or better means to attain them.

In the sections that follow, we shall attempt to show how the assumptions of long-run profit or utility maximization are non-operational even if,

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[1]Opinion on this is mixed. Some writers will not admit any valid aim of the firm other than to maximize long run profit. Others, while still adhering to the general tenets of organizational maximization will allow a broader conception of organizational aims subsumed under a utility function.

logically or tautologically, they can be shown to be valid. Without attempting to trace their complexities of development, we shall describe certain outgrowths of the profit maximization theory of organization as the conflict with the realities faced by business firms, even in those areas which are generally considered the province of economic research. Finally, we shall present some examples of a line of research which a few workers have been following in an attempt to gain some knowledge in the area of organizational designs for goal-oriented organizations.

Short-Run Goals Formulated by Organizations

It seems reasonable to accept, as a descriptive proposition, the notion that the ruling coalitions[1] of an organization and subunits within the organization formulate certain goals for the future activities of these organizational units. It is obvious from the pronouncements of corporations that goals may be stated in the context of profit--the traditional measure of organizational performance in economic theory--or other variables which, albeit possibly translatable into the context of long-run profit, are rarely explicitly formulated in profitability terms. It is quite possible that a stated goal to "increase our share of the market from ten to twelve percent" is more closely related to long-run profit than a goal to "increase our profit from ten to eleven million dollars" over the same time period. It is, however, simply impossible to find evidence that firms do construct explicit long-run profit functions from which they derive these short-run statements of purpose.[2]

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[1]This term is in the context of the "behavioral theory of the firm" as developed by Cyert and March, (1963).

[2]See, for example, Cyert, Dill, and March (1958).

Other short-run goals found to be formulated by organizations are even less easily translated into profitability terms than those of the order of a "share of market" goal. Goals which are related to employee satisfaction and morale are a case in point. These may take the form of a policy--e.g., "we will not lay off employees," or "we will not reduce an employee's salary if we reclassify a job"--which places constraints on the organization's ability to maximize short-run profits. Although it has frequently been suggested that morale is related to productivity,[1] the overwhelming weight of the evidence suggests that while certain constraints on a level below which certain "morale variables" should not fall may be advisable,[2] the relationship between morale and productivity is at best highly conditioned by other situational factors.[3] Whether or not corporate executives feel that the long-run effects of policies designed to promote employee security and welfare are felt in increased profitability it is clear that a "no layoff" policy, for example, may be extraordinarily costly in the short run and may limit severely the flexibility available in organizational planning in the longer run.[4]

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[1]See Likert (1961) for a summary of the empirical studies whose aim was to confirm a positive relationship between morale and productivity.

[2]Hertzberg, Mausner, and Snyderman (1959) provide a form of evidence on this point.

[3]Brayfield and Crockett (1955) present a "box score" of the studies pro and con based on the hypothesis that morale and productivity are positively related. Hertzberg, Mausner, and Snyderman (1959) suggest that the satisfaction of some needs is required but, above these minimum levels, increases are not accompanied by better performance, Stedry (1964) discusses the relevance of particular studies which failed to find a positive relationship to the problems of organizational control. Vroom (1964) presents an excellent summary of the available evidence in this area.

[4]As, for example, the model of Holt, Modigliani, Muth and Simon (1960). In their model, work force is seen as a variable, with specified costs of layoff, retraining, and training of new employees. While they do not include possible costs of deleterious effects of layoffs on the morale of remaining employees, it is clear that assuming an infinite cost of layoff--i.e., a "no-layoff" policy--could produce a substantial departure from optimality.

While frequently rationalized to stockholders and others as contributory to organizational effectiveness the evidence that such limiting policies are necessary to insure profitable companies does not exist. The current generation of corporate executives may simply prefer to have secure, reasonably contented employees than insecure, unhappy ones. There are probably very few who will send a worker with thirty years' service "out on the street" no matter how ineffectual he has become although it would be impossible to assess the dollar cost or contribution to long-run profit of a policy which is probably best described as "simply humane." In order to be consistent with the evidence (or lack of it) concerning a relationship between policies and constraints aimed at producing a high level of employee morale and the traditional profitability measures, one must treat such policies as separate and perhaps independent goals.

Such policies are only examples of organizational aims which may be more conveniently considered as ipso facto goals rather than as a part of an all encompassing utility function. Goals which may have a direct but quantifiable role in the determination of organizational profitability may be discerned. Company "image," community relations, civic pride, patriotic endeavor have all at one time or another been among the stated goals of corporate managements. Whether or not such aims actually do, or are perceived to, contribute to corporate profits may be irrelevant. What is quite obvious is that given the present capability to predict the effect on profitability of changing such variables, any precise formulation of corporate objectives depends upon the specific statement of the objectives per se rather than inclusion in a profit function rendered markedly subject to error thereby.

The Normative Relevance of Short-Run Goals

It is not sufficient, of course, to show examples of non-optimal behavior. The neo-classical economic model would require that a firm maximize long-run profit subject to technological constraints, i.e., eliminate irrationality. If, however, the demands of the market or society or technology preclude rationality as a viable concept at the organizational level, a stronger case may be made for a need for new kinds of normative models. It will be instructive to examine some of these demands -- one generally considered within the province of economic analysis in detail -- as examples in support of this need.

The financial community, perhaps "irrationally," places constraints on the firm's ability to borrow.[1] A firm may simply be unable, no matter what interest rate it is willing to pay, to borrow beyond a modest percentage of its total equity.[2] Furthermore, it is reasonable to believe that what is considered "good risk" leverage in one period may be a "poor risk" in another. A firm may thus desire to maintain a degree of leverage well below that of the maximum it can borrow at a time when additional funds would be "nice to have" in order to maintain a reserve against a time when funds would be desperately needed. Since the latter is not unlikely to come

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[1]Chambers and Charnes (1961) have shown, for example, the extremely low loss ratio allowed by a bank's policy in obvious contradistinction to a policy of charging higher interest rates to compensate for making loans with more risk. Clarkson's (1962) simulation of a trust officer shows similar "cut rules" as opposed to a rate-risk continuum.

[2]While Modigliani and Miller (1958) have shown that assumptions relating leverage to cost of capital can be shown, through the use of aggregated data, to produce empirically verifiable hypotheses, the possibility that the relatively restricted ranges of both equity and the cost of capital observed are attributable to constraints on the extent of leverage remains. Other investigations such as Farrar's (1962) have provided evidence for quite severe limitations of risky investments in the portfolios of certain classes of investors.

at a time when leverage requirements of lenders are most stringent the relevance of a current borrowing limit for long-term debt is unclear. While possibly evidence of "irrationality," numerous examples of companies with no long-term debt in their capital structures exist.

It is certainly not difficult to envision a policy that long term debt not exceed some percentage of total equity even if the current borrowing limit has not been reached and investment opportunities exceed the cost of capital. While such a policy may reflect inadequate understanding of the dynamic processes underlying future investment opportunities, the normative theorist is generally faced with the problem of maximizing (or satisficing) relative to known, rather than unknown, parameters in his models.

Yet, the predictability of the effects of capital budgeting decisions would seem to be of an order much greater than that in other areas -- e.g., personnel policy. When, in an area as seemingly well-defined as capital budgeting, no satisfactory dynamic model for optimal decision-making exists except where deterministic returns may be assumed,[1] of what use, in a normative sense, are models which assume the capability of making long-run optimal decisions "across the board" in all areas of management endeavor?

We are, we think, not attempting to provide a justification for formulating models whose purpose is to "hold the line" while bridging temporary gaps in our knowledge of the world and the predictability of future events. Rather it appears that, as our knowledge is growing, so is the number of areas which will be included in a definition of organizational "welfare." Performance measurement and determination of causality may well be more difficult in new areas which seem to be emerging. It is feasible, if

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[1] See Weingartner (1963).

perhaps undesirable, that the future corporation will endeavor to satisfy more and more individual needs of satisfaction and fulfillment. Selznick (1963) for example, suggests that individuals in future generations should obtain a greater share of their satisfactions, social intercourse, needs for self esteem and achievement, etc., from the organization in which they work. Should Selznick's criteria, for example, be adopted by an enterprise, much more specific knowledge of individual needs -- psychologically and psychiatrically -- would be required for implementation than for the more modest aims of profit, market share, and a modicum of employee security. It is not inconceivable that the monetary gains made through automation, advanced information-processing and optimal programming schema will be used in part to increase the "affluence" of organizational employees in non-monetary as well as monetary terms. These may, of course, be looked upon as "by-products" of long-run profit maximization or as candidates for incorporation in an "organizational utility" function.

But are we to assume that future generations of corporate management could (or would want to) formulate complex "organizational utility" functions which include these additional individual rewards? The complexity of such (hypothetical) functions, including interdependencies introduced by the dependence of one person's satisfaction with his lot on another's rewards and the not-soon-to-be-understood relationship between individual satisfaction and other aspects of organizational performance, is awesome. The task of formulating such complex utility functions would seem to provide an insurmountable obstacle even if computationally feasible solutions may be shown to exist for finding their optima. It would seem that to adopt as normative construct the premise that each individual firm <u>should</u> Maximize an "organizational utility" function would be to require each

firm to formulate and maximize a welfare function of an order of complexity not appreciably less than that of a social welfare function for the society as a whole.

The practical difficulties confronting an attempt to construct an all-inclusive long-run profit or utility function can, of course, be explained away by assuming a "cost of information;" i.e., one can construct as simple a function as one chooses provided one assumes that the cost of formulating a more complex one, or finding its optimum, is prohibitive. On this basis, all behavior can be (and has been) described as "rational"[1] although our observations tell us, to parody Mr. Orwell, that some behaviors are more rational than others. Moreover, if all behavior is rational, of what use are normative models of rationality? It would seem, then, that in order to adopt long-run profit or utility maximization as a normative construct one must either assume a level of knowledge far in excess of that which exists or will exist in the foreseeable future or adopt a prohibitive cost of information which negates the need for normative constructs.

We have attempted to argue that little convincing evidence exists that would imply that organizations maximize profit or utility. We have also attempted to argue that at least one common justification for a proposition that they can maximize expected utility rests upon an assumption which, carried to its logical conclusion, also implies that they do. We do not mean to imply that insights gained from long-run maximization models are not of value. Rather, we are attempting to provide for the admissability of normative models of organizational behavior which incorporate the tools developed in the process of economic analysis but which do not focus on an all-inclusive

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[1] See, for example, Luce and Raiffa (1958), particularly Chapter 2, for a discussion of the ways in which utility theory may be made to fit all behaviors.

utility function. Such models might define an organization's (or its ruling coalition's) criteria in terms of its desires to attain certain short run goals and achieve conformity to organizational policies without attempting to justify these short run aims or policies in terms of a long-run function.

Assumptions of Normative Decision-Making Models

The development of normative models for the purpose of making better decisionsas to, for example, production and distribution schedules -- generally classified as operations research -- may be perceived as occupying a place somewhere between the two extremes of profit maximization for the firm as a whole and entirely descriptive research. Their purpose is normative but in the course of formulating models the processes with which the models deal must be described in considerable detail. Furthermore, these models have generally been developed in response to real problems observed to be extant in industrial organizations. These models most often have maximization of a criterion function as their aim but, unlike maximization of profit or utility at an organizational level, the criterion function is credible. Intuitively there is little to be gained by having a non-optimal gasoline blending operation when an optimal solution is readily available. The problems of organizational aims noted in the earlier sections of the paper are not particularly relevant in the selection of a criterion function for many kinds of models; it is better to have less than more cost-given constraints on the availability of inputs, blending capacity, etc.

The departure of such models, however, from the quest for global --i.e., for the organization as a whole -- optima should be clear. The constraints of the organizational sub-problems are not derived from a decomposition of

a global maximization problem. They are derived from externalities to the problem which are not themselves optimally determined. Although certain techniques such as linear programming provide information about the cost or profit advantage to be derived from altering the constraints, no real claim can be made that the problem solution is part of an optimum "in the large." The constraint set is not optimally determined nor will alterations in that set undertaken on the basis of information obtained from the model render the set optimal even if increases in profitability can be clearly demonstrated.

Needless to say, the applications of operations research have gone far beyond cases where the constraints and parameters of the problem chosen for the solution were or could be derived from decomposition of an all-inclusive optimization problem. Indeed, such cases are probably non-existent. The application of operations research models which provide only optima in the small can be encompassed within global maximization assumptions on the basis of a "prohibitive cost" of constructing an integrated model or even a larger model than those applied. Alternatively, one can take, as a management aim, the optimization of certain aspects of its operations without the desire to maximize some global organizational criterion. This latter construction avoids the necessity to assume or compute the (frequently unestimable) cost of constructing larger models. Also consider the obvious paradox which arises when a cost of additional modeling under existing technology is "prohibitive" at one point in time, but by management decision is undertaken without substantial advance in technology at another. The introduction of optimization models into a "satisficing" organization does in fact seem to avoid some of the circuitous reasoning required to introduce then into a "rational" organization.

Although it would seem obvious that most operations research modeling and application have occurred in situations where the constraints and parameters of the models used have resulted from management decisions external to the models, explicit recognition of this fact has been rare. Indeed, large classes of models such as the S,s inventory models typified by the research of Arrow, Harris, and Marshak (1951) have been formulated as though they were global maximization problems. A "cost of capital" has been assumed rather than limitations of capital that could be invested in inventory; a "storage cost" rather than a warehouse constraint has been utilized. Other models such as the great bulk of linear programming models have been less imitative of the assumptions of classical economics but fall short of explicit recognition of some kinds of management decision. They allow technological constraints -- machine capacities, required sequences, etc., -- rather than incorporating additional capacity "at a cost" or an infinity of different possible operations to replace the current one at some cost or another. However, although most technological constraints result from a management decision of one kind or another -- e.g., a decision not to buy a bigger machine -- specification of constraints whose tangible physical properties are not a priori apparent is infrequent, at least in the published literature.

Explicit recognition of the validity of management's imposing, by fiat as it were, policy constraints on the maximization problem is an important step in increasing the usefulness of operations research models in the context of management decison problems of broad scope. An example is provided by Charnes, Cooper, and Miller (1959) who specify a minimum cash balance constraint as a management desideratum in addition to the usual technological constraints. The short-run cost of capital implied

by the constraint may then be imputed by using the dual variable associated with the cash balance constraint, thus serving as a guide to future management decisons. Explicit recognition is thus made of the fact that in the final analysis it is management, rather then the linear programming model, which must decide what price it is willing to pay to maintain a liquidity position.

The models to be described below are closely related to the operations research methodology. They represent, however, further extensions of the principle of attaching validity to management decisions made as to goals and policies with or without explicit recognition of the economic impact of those policies. The solutions derived using these models are, like operations research models, prescriptions for behavior. However, based upon actual goals that management do set for their organizations, they are prescriptions for optimal behavior vis a vis the stated and observed desires of management rather than a hypothetical long-run profit or utility maximization.

Chance-Constrained Programming

Management goals are frequently stated in terms such as "we aim to" or "our policy is" rather than "we must." The deterministic constraints of usual linear programming models are stated, by contrast, as requirements -- absolute constraints. A minimum cash balance, for example, would need to be stated as "we aim to keep cash at or above $100,000 with probability equal to 1." In order to make this into a goal or policy as we normally understand these terms the requirement of the unit probability must be relaxed. It is quite clear that there would be circumstances in which a firm might violate any policy or forego the attainment of a goal. The

frequency with which these violations occur is, in some sense, a measure of the degree of adherence desired to a particular aim.

In response to this problem, Charnes and Cooper (1962) have developed models incorporating "chance constraints" which replace, in a linear programming framework, some of the usual constraints of the form:

$$\sum_{j=1}^{n} a_{ij}X_j \geq b_i$$

where the X_j are the variables, the a_{ij} parameters and the b_i requirements with probabalistic constraints of the form:

$$P\left\{\sum_{j=1}^{n} a_{ij} X_j \geq b_i\right\} \geq 1 - \alpha_i$$

where $P\{X\}$ is the probability of occurrence of X and α_i the maximum probability allowed for non-satisfaction of the constraint. In this form the b_i become goals. Charnes and Cooper refer to the expression in this form as the statement of a "policy;" e.g., a "policy" of satisfying all customers from stock (i.e., no order backlog) is not taken seriously as a zero probability of stockout but a low probability of stockout.

It may well be easier to assess the tolerance limit of customers in terms of the proportion of times they will tolerate being turned away than to assess a "cost of stockout." One of the authors has observed (1962) that in constructing an optimal inventory scheme for a military supply system, "cost of stockout" was essentially an unestimable quantity, while establishment of tolerable stockout probabilities for different classes of items was eminently practicable. In other situations a firm may desire to have satisfied customers even if it is costly to short run profit or even long run profits (if, of course, the benefit of having "satisfied customers" could be adequately assessed).

Examples of inventory control policies are familiar, of course, but chance constraints can express policies -- e.g., "no" layoff -- as well. The dual variables provide the benefit or cost to the optimal solution of altering the percentage of non-conformity to policy which will be tolerated. Whether or not organizations should (from the standpoint of "rationality") formulate policies, or in the language of this paper set goals, they apparently do. Chance constrained programming offers one method of expressing policies or goals in such a way that optimization of short run profits or profits over a finite horizon can be maximized while offering an evaluation of the costs of these policies as well. A policy which is found to be extremely costly may be re-examined and perhaps altered to an equally desirable policy (on other counts), or eliminated.

Goal Programming

In another approach to the goal setting or policy formulation problem, Ijiri (1963) and Charnes, Cooper, and Ijiri (1963) have stated an optimization problem entirely in terms of minimization of the extent of non-conformity to goals. Their goal-programming models consist, in addition to those of the mentioned types of deterministic constraints of the form:

$$\sum_{j=1}^{n} a_{ij} X_j + Y_i = b_i$$

where Y_i is the distance from adherence to the policy:

$$\sum_{j=1}^{n} a_{ij} X_j \geq b_i$$

The functional in the problem can be an unweighted sum of the non-conformities or a weighted sum such as

$$Z = \sum_{i=1}^{n} C_i Y_i$$

to be minimized assuming that all policies are not viewed as equally important. If all of the goals can be attained, a trivial solution is obtained with Z = 0. The applicability of these models is to problems where goals conflict and cannot all be simultaneously attained.

Many variations of these models are possible, such as combining a profit function with the goal conformity functional. Combining this concept with that of chance constrained programming could yield interesting models in which a function of the X_i, or the Y_i, or both could be minimized. The concept remains, however, the perception of several goals to be attained or policies adhered to rather than simply a single profit or utility function.

Multiple Goal Models

The authors have presented elsewhere (1964 a,b) and (1962) models which combine the stochastic character of chance constraints with the concept of goal programming. In these models, we have specified the probabilities of attainment of independent goals as functions of the managerial effort allocated to attainment. In particular, functions of the form:

$$\left\{X_j \geq a_j\right\} = k_j \left(1 - e^{-\alpha_j P_j}\right)$$

have been used where P is the probability operator, X_j the actual performance, a_j the performance goal, P_j the effort allocated to attaining the jth goal, α_j an arbitrary constant, k_j a limiting probability of attainment as P_j grows large. This function has certain desirable properties for representing response to effort -- diminishing returns to scale and asymptotic approach to a limiting probability -- and because it is monotone increasing and concave, mathematically convenient. Other functions are possible, of course, but our investigations to date have been concentrated on this one to provide an example of what can be done with several kinds of criterion functions.

One possible criterion of success of a program involving goal attainment is obtained by assuming that goal attainment carries a reward, r_j and non-attainment a penalty, p_j. Then a reward function may be formulated as:

$$R = \sum_{j=1}^{n} r_j z_j^+ - \sum_{j=1}^{n} p_j z_j^-$$

where $z_j^+ = 1$ where $X_j \geq a_j$ (i.e., where the goal has been attained) and 0 elsewhere and $z_j^- = 1$ where $X_j < a_j$, 0 elsewhere. If one wishes to maximize expected reward, it is readily perceived that:

$$E(z_j^+) = (1)\left[P(X_j \geq a_j)\right] + (0)\left[1 - P(X_j \geq a_j)\right]$$

and

$$E(z_j^-) = (1)\left[1 - P(X_j \geq a_j)\right] + 0\left[P(X_j \geq a_j)\right]$$

so that the expected reward function may be expressed as:

$$E(R) = \sum_{j=1}^{n} \left[(r_j + p_j)\, P(X_j \geq a_j) - p_j\right]$$

A function such as this may be perceived as similar to one faced by a supervisor in an organization who has budgets to meet in several areas -- labor cost, material cost, overhead, etc. -- with differing levels of importance attaching to each budget as reflected by the weights $(r_j + p_j)$. We have presented a solution to this maximization problem in Charnes and Stedry (1964 a) and shown (Stedry, 1964) that for the exponential density by appropriate choice of $r_j + p_j$ and a_j, a supervisor who would set out to maximize the expected reward function would allocate his effort so as to maximize the function:

$$E(\pi) = \sum_{j=1}^{n} \beta_j E(X_j)$$

where the β_j are the contributions to profit of a unit of X_j. This kind of equivalence suggests the possibility that a supervisor who "irrationally"

looks at budget attainment rather than expected profit as related to his reward and a management which "irrationally" sets budgets rather than telling him to maximize expected profit can combine to produce "rational" behavior in the economic sense. A possible solution to some of the problems of a disparity between normative and descriptive organizational models may be one of utilization of patterns of observed "irrational" behavior to produce, through using instructions more meaningful to individuals than profit maximization, behavior which is closer to "rational" behavior in the economic sense, if this is considered desirable.

Other forms of goal attainment criteria found in practice are conceptually further removed from expected utility models. Specification for a new product are a case in point. In order to be acceptable, a plane must fly X miles per hour, have a range of Y miles, an altitude of Z miles, etc. Trade-offs among such specifications are no doubt possible, but if a transatlantic airliner cannot fly across the ocean without refueling, no increase in speed or altitude will render the craft suitable for its intended use. Given a set of contract specifications, minimum acceptable performance in the jth area denoted by a_j and actual performance by X_j, a performance criterion might be the maximization of the joint probability of occurrence of attainment of all the goals, or:

$$P = P(X_1 \geq a_1,\ X_2 \geq a_2,\ \ldots,\ X_n \geq a_n)$$

One can, of course, transform this into an expected utility maximization model by denoting the utility of joint attainment as 1 and of non-attainment as 0. Then denoting utility by U, we have:

$$E(U) = (1)(P) + (0)(1 - P) = P$$

This ex post facto transformation, however, adds nothing to understanding of the criterion function. The explicit recognition that the various

performance levels are of no value unless all of them attain some minimal standard can only be obscured by imposing discontinuous utility functions even though this can be done, and in some cases, might be convenient for computational purposes.

We have developed an algorithm for an approximate solution to the probability maximization problem (Charnes and Stedry, 1964 b) where the attainment of each of the several goals is viewed as stochastically independent of the others, with functional independence introduced through a constraint on total effort. The problem, using the exponential form of effort response is stated as:

Maximize:

$$P = \sum_{j=1}^{n} \left[k_j (1 - e^{-\lambda_j \rho_j}) \right]$$

Subject to:

$$\sum_{j=1}^{n} \rho_j \leq \rho$$

The precise form of the solution which, because no readily available analytical solution exists, involves tedious application of methods for finding approximate solution and error limits on the approximation is beyond the scope of this paper. Variations of this model are of interest, one of which we have investigated (Stedry and Charnes, 1962). There we postulate one set of levels as "minimum standards," a_j, all of which must be attained with probability at least W, as well as "desirable levels," a_j, whose attainment is associated with reward.[1] This problem can be stated as:

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[1]Through the possible construction of equivalent expected reward maximization and profit maximization models indicated above, this problem could also be comprehended as expected profit maximization subject to a minimum standard constraint.

Maximize:

$$E(R) = \sum_{j=1}^{n} r_j \, P(X_j \geq a_j') = \sum_{j=1}^{n} r_j \, k_j' \, (1 - e^{-\alpha_j f_j})$$

Subject to:

$$P = \prod_{j=1}^{n} P(X_j \geq a_j) = \prod_{j=1}^{n} \left[k_j \, (1 - e^{-\alpha_j f_j}) \right] \geq W$$

$$\sum_{j=1}^{n} f_j \leq f.$$

where the primed parameters relate to "desirable" levels of performance, the unprimed to "minimum acceptable" levels. This may be comprehended as representing the not unfamiliar situation where "kudos" are given for performing at a level noticeably higher than "minimum acceptable" but where failing to achieve acceptable performance in any area can cancel out the benefits of good or exceptional performance in others.

Other variations, of course, are of interest. With relatively little increase in complexity, chance constraints can be placed on levels of attainment in individual areas. Although we have not investigated a vast array of goal structures observed in practice, our investigations have shown the feasibility of formulating optimal solutions to problems couched in terms of goal attainment. While these models share with profit and utility maximization models the optimization of a single criterion function, the resulting solutions can frequently be simplified into heuristics sufficiently simple that an individual might be able to use them in lieu of the maximization model.

For example, for the reward maximization model, the supervisor faced with a budget should allocate effort to areas with the areas where $a_j(r_j \div P_j)k_j$ is large before those where this product is small. He should not allocate effort to any area where he does not have a "reasonable"

probability of attainment. Once he has decided which areas are on his "list" a first approximation of the optimum allocation within the list is to make α_j a constant. A somewhat better one is to make the α_j proportional to $1/\alpha_j$ or $\left[\alpha_j(r_j + P_j)k_j\right]$ -- although at this level of complexity we seem to be sufficiently beyond "simple heuristics" that a computerized decision rule which need not be limited in its complexity seems desirable. For the probability maximization model a good heuristic would be to allocate effort so as to equate the probabilities of attainment of the individual goals.

While such heuristic solutions are not capable of providing optimal allocations of effort, they may serve as a guide to formulating behavioral hypotheses for test. It is unlikely that a supervisor in a manufacturing plant will find the optimum solution and allocate his effort accordingly. However, he may operate according to a heuristic which roughly equates the probabilities of attainment of his various budgets. If so, budget setting might then be accomplished with the aid of the mathematical model which corresponds to this heuristic -- the probability maximization model -- setting budgets which would provide optimal allocations if the optimal solution were used but providing sufficiently good allocations with the simple heuristic.[1]

At present, no models exist for statistically dependent effort response functions. The exponential functions we have used, borrowed form the theory of search (Koopman, 1962) and embellished, can be viewed only as an example of the existence of solutions to certain types of problems. Much

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[1]Attempting to alter effort allocation directly would seem to be of limited value. In one study reported by Rubin (1963) it was found that "time spent" in various substantive activities was badly communicated through an organization and that little correspondence existed between how supervisors wanted subordinates to allocate their time and what subordinates thought their superiors wanted them to do.

more work is necessary before individuals' response to goals can be used in any systematic way to design optimal or quasi-optimal goal structures.

Experimental Investigation

A word should be said about the kinds of reality testing of models which might be fruitful for expanding goal-oriented theories of organization. Of particular interest is an experiment performed by Churchill (1962). His experiment dealt with conflicting goals, while he, acting as supervisor to his subjects, directed them both to find the best solution to the problem, and to follow a procedure which gave "good" solutions (but not the best solution). He examined the effects of subjects' performance when an audit (of procedure) was announced and took place, when it was announced but did not take place, etc. He worked with two different subject groups -- students and clerks -- and the effects of audit differed. The student subjects, who were generally capable of finding better solutions than the procedure would provide (although they made errors which they would not have made following the procedure), gave poorer over-all performance as the emphasis on audit increased. The clerks, however, benefited from procedural emphasis which caused them to conform more closely to procedures which gave good solutions, although "too much" emphasis seemed to result in a deterioration of performance (perhaps from nervousness resulting from repeated audits). Although this study is oriented toward investigating the role of the auditor, generally considered external to the day-to-day business operation, it is a pioneering effort in using the psychological laboratory to study the effect on performance of techniques for enforcing conformity to policy and procedure -- techniques which are ubiquitously used in contemporary organizations.

An experiment was carried out in a field situation in an attempt to study the effect of the difficulty of attainment of goals set for engineering foremen on their performance. Although the sample size was too small to provide conclusive findings, Stedry and Kay's (1964) results suggest that difficult goals may produce extremes in performance. Foremen in their study who had difficult goals generally showed large improvement or large decrements in performance while those with "normal" goals generally showed modest improvement or decrement. Those who stated that they perceived their goals as impossible showed large decrements in performance but so did a few who perceived their goals as challenging. Strong correlation (negative) between performance improvement and age among foremen with difficult goals suggests that individual differences in response must be considered in the design of any goal-setting procedures.

In another field situation Haberstroh (1961) took advantage of a "natural" experiment -- i.e., a change which takes place in the organization which allows before and after measures but is not under the direct control of the experimenter -- to investigate the response to changes in safety goals in a steel mill. The number of systematic investigations of performance response to goals and the usual techniques of managerial control is, unfortunately, small. We know very little about human response to goals either individually, in groups, or in large organizations.

Some Suggestions for Future Research

In this paper, we have attempted to bring together some of the work which is directed toward closing the gap between descriptive theories and normative models of organizational behavior. This work shares a focus on the processes with which organizations are observed to operate -- setting corporate goals, formulating policies, setting budgets -- but with an emphasis on the means of doing these things more systematically.

Integration of the experimental and model-building approaches is difficult. We can observe phenomena much more complex than we can model. On the other hand, to vary conditions in the laboratory systematically is extraordinarily more difficult than varying parameters in a model. Experiments conducted under actual organizational conditions are incredibly costly and designs which vary more than one thing at a time almost impossible to implement. This makes the random testing of behavioral hypotheses for the purpose of designing improved organizational control systems prohibitively costly. It is probably economical to pursue extensive model-building activity in an attempt to find out in advance what behavioral propositions are sufficiently promising to justify the cost of experimental testing.

The direction in which this research will lead us is at present unclear. Just how much will be learned about human behavior is an open question as is the limit to how much one can use this knowledge to attain organizational goals without infringing on individual rights. Perhaps an ultimate goal is an organization whose control system is designed so that the attainment of goals set for employees at all levels of the organization contribute to organization goals. This is not to say that all employees in an organization need be committed to organization goals; e.g., it is not necessary that the lathe operator be committed to increasing the company's market share. Rather, it is necessary that we can design a set of goals and rewards for that lathe operator such that, by pursuing what he considers to be his own best interests, with whatever forms of rational or irrational decision rules he follows, he will contribute as much as possible to the attainment of organization goals. It is probable that goals and policies which contribute to employee and community welfare, whether or not justified on profitability grounds, will continue to exist -- at least among organizations sufficiently affluent to afford them.

In any event, a good deal more research must be done before any claim to a satisfactory system of controls or designs for subgoals at the various levels in the organizational hierarchy can be made. At present, our control systems are hampered both by an inadequate knowledge of their behavioral effects as well as an absence of techniques for fitting these probabilistic response patterns into a coordinated pattern for the organization as a whole. It is hoped that these areas will be subject to extensive investigation.

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